



Athletic movement competency of semi-elite, adolescent, female, rugby league athletes

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Abstract

Objectives: To quantify movement competency in adolescent female rugby league athletes using the Athlete Ability Assessment and compare outcomes with age-matched male athletes to identify sex-specific differences.

Design: Observational, cross-sectional study.

Methods: Thirty female athletes (16.0 ± 1.0 years) competing in the Queensland rugby league competition completed the Athlete Ability Assessment (AAA), comprising six tasks, overhead squat, lunge, single-leg Romanian deadlift, and push-up. Task scores and total AAA scores (mean \pm SD) were compared with a previously assessed age-matched males. k-means cluster analysis using the six task scores classified female athletes into lower- and higher-skilled groups. Between-sex and -group differences were assessed using Mann–Whitney U tests. Effect sizes were calculated using rank-biserial correlation coefficients (r) and interpreted as small (<0.30), moderate (0.30 – 0.49), or large (≥ 0.50). Statistical significance was set at $p < 0.05$.

Results: Females demonstrated significantly lower total AAA scores than males (30.0 ± 7.9 vs. 34.7 ± 4.1 , $p < 0.001$), with lower scores across all tasks except push-ups. Females scored higher on left and right single-leg lunge tasks ($p < 0.001$). Sex comparisons revealed moderate to large effect sizes across tasks. Sub-analysis identified distinct lower- and higher-skilled females, differentiated by overhead squat ($r = 0.955$), single-leg lunge (left $r = 0.783$, right $r = 0.819$), and total AAA score ($r = 0.814$).

Conclusion: At entry to the talent development pathway, female rugby league athletes exhibited lower movement competency than males, alongside substantial inter-individual variability. These findings support movement-competency-led, sex-specific strength and conditioning approaches. The AAA provides a practical tool to stratify athletes and guide safe progression toward higher-load strength and power training.

Keywords

Biological maturation, injury prevention, multi-joint strength tasks, neuromuscular control-based assessment tools, talent development

Reviewer: Josh Secomb (University of Newcastle, Australia)

Introduction

Female participation in traditionally male-dominated sports such as rugby league is increasing rapidly, yet retention remains a critical issue, with 50% of players aged 15–17 leaving the sport.¹ This sharp dropout rate coincides with a period of heightened injury risk, much of which is linked to sex-specific anatomy and biomechanics^{2,3} including higher rate of concussion,⁴ anterior crucial ligament injury, ankle instability, hip impingement, and overuse injury.^{5–7} These elevated risks highlight the importance of understanding how sex-specific musculoskeletal differences intersect with talent development frameworks, and how they may influence both performance and long-term athlete

retention. To address this, it is necessary to examine adolescent females as they enter talent development pathways during a period of rapid anatomical change and increased vulnerability.

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Females aged 15–19 years are identified as potential talent for elite competition and invited into talent development programmes, which aim to accelerate multidimensional skill acquisition and sustain depth for national and international selection.⁸ For female athletes, entry into development pathways coincides with pubertal hormonal changes that drive musculoskeletal restructuring, including pelvic widening, lower acetabular repositioning, altered spinal and limb alignment, and increased joint laxity.^{9,10} These adaptations influence muscle attachments, movement mechanics, and strength development.¹¹ Collectively, these factors contribute to distinct injury profiles for female athletes and emphasise the importance of sex-specific strength and conditioning practices.^{6,12,13} Accordingly, accurate assessment of athletic movement competency prior to, and during, participation in development pathways is critical to inform appropriate training progression and injury risk management. However, normative movement competency data for adolescent female athletes are currently lacking, limiting the ability of strength and conditioning practitioners to individualise training strategies and safely progress training loads.

The Athlete Ability Assessment (AAA) is a valid and reliable tool to objectively assess movement competency.^{14–16} Preferred over the Functional Movement Screen™ in collision sports, the AAA has been adopted for rugby union,^{14,17} Australian football,^{15,18} and rugby league,^{8,19} athlete monitoring. The AAA includes tasks such as the overhead squat, single leg lunge, single-leg Romanian deadlift, and push-up, each evaluated against detailed criteria that enable biomechanical analysis.²⁰ The AAA battery reflects movements of key tasks undertaken during rugby league competition. For example, the overhead squat assesses trunk control and posture relevant to tackling, ruck engagement, and directional changes.^{8,14,19} Push-ups mirror upper body endurance and core demands for contact efforts including tackling and defensive ruck control, while single leg movements reflect unilateral force production, deceleration, and joint stability essential for high-speed and contact tasks.^{8,16} Although the AAA has been used to establish athlete ability and monitor movement competency over time,^{15,19} its application has largely focused on descriptive profiling¹⁵ rather than providing benchmark data to guide strength and conditioning decision-making, including safe progression of training loads. This limitation is particularly evident in adolescent female rugby league athletes, for whom normative movement competency data are scarce. Therefore, the present study aimed to characterise movement competency in adolescent female rugby league athletes using the AAA battery. In addition, AAA outcomes were compared with prior comparable male rugby league athletes, to identify potential sex-based differences in movement competency that may inform the

development of sex-specific strength and conditioning practices within talent development pathways.

Methodology

Ethics approval

Ethical approval was granted from James Cook University (16956) with all participants and parents/guardians providing written informed consent prior to data collection.

Research design

This study involved an observational research design where female participants completed a battery of athletic movement competency (i.e., modified AAA) at the beginning of the pre-season phase, after 10 weeks of no structured training (i.e., Christmas holidays). Athletes were recruited from local club and high school rugby league competitions.

Participants

The participant pool comprised a convenience sample of 30 female adolescents (16.0 ± 1.0 years) from two clubs registered to compete in the Queensland Rugby League statewide competition. For comparison, a convenience sample of 52 male adolescents (17.0 ± 1.0 years) competing within the same Queensland Rugby League competition was included. Both female and male cohorts consisted of athletes entering formal talent development pathways through comparable rugby league recruitment processes. All participants were free from injury at the time of assessment.

Detailed histories of structured strength and conditioning exposure and rugby league-specific training experience were not collected, which should be considered when interpreting between-group differences in movement competency.

Athletic movement skill assessment via AAA

Participants completed a modified AAA battery of six tasks, and each task employed three criteria with each criterion being scored out of three (Table 1) for a total score of nine for the AAA battery task. The AAA²¹ was modified by decreasing the repetitions for the push-up from 30 to 10, given known sex- and maturation-related differences in upper-body strength,²² to minimise fatigue-induced decrements in neuromuscular control and movement quality. Previous work has demonstrated that core and trunk fatigue significantly reduces movement competency scores in female athletes, particularly during stability-dependent tasks such as the push-up, independent of mobility limitations.²³ Participants were scored according to the practice reported by McKeown et al.¹⁵ with a score of 1 = poor,

Table 1. Modified AAA used to assess athletic movement competency as adapted from.²¹

Movement	Assessment points	3	2	1
OHS	Upper Quadrant	Perfect hands above head / feet	Hands above head / feet	Unable to achieve position
	Triple Flexion	Perfect SQT to parallel	SQT to parallel (compensatory)	Unable to achieve position
	Hip Control	Neutral spine throughout	Loss of control at end of range	Excessive deviation
SLL left	Hip, Knee, Ankle	Alignment during movement	Slight deviation	Poor alignment
	Hip Control	Neutral hip position	Slight deviation	Excessive flex / ext
	Take off Control	Control	Jerking	Excessive deviation
SLL right	Hip, Knee, Ankle	Alignment during movement	Slight deviation	Poor alignment
	Hip Control	Neutral hip position	Slight deviation	Excessive flex / ext
	Take off Control	Control	Jerking	Excessive deviation
RDL left	Hip Control – Frontal	Maintain neutral spine	Slight flex / ext through hips	Excessive flex / ext on SL stance
	Hip Control – Sagittal	No rotation	Slight rotation at end of range	Excessive rotation
	Hinge range	Achieves parallel	Can dissociate but not reach parallel	Cannot dissociate hips from trunk
RDL right	Hip Control – Frontal	Maintain neutral spine	Slight flex / ext through hips	Excessive flex / ext on SL stance
	Hip Control – Sagittal	No rotation	Slight rotation at end of range	Excessive rotation
	Hinge range	Achieves parallel	Can dissociate but not reach parallel	Cannot dissociate hips from trunk
Push Up	TB control	Perfect control / alignment	Perfect control / alignment for some	Poor body control for all reps
	Upper Quadrant	Perfect form / symmetry	Inconsistent	Poor scap. positioning for every rep
	X10 reps	Hits target count	-	<10

OHS = overhead squat; SLL = single leg lunge; RDL = Romanian deadlift; scap = scapular, flex, flexion, ext, extension, rep, repetitions.

unable to perform specific task; score of 2 = inconsistent performance of the specific task or slight deviation from the ideal; and score of 3 = perfect performance of task. Reliability of the AAA scoring has been previously established, with strong intra-rater agreement reported in our earlier work.⁸ Given the categorical nature of the AAA scoring criteria, the primary investigator assessed scores for AAA battery tasks for ten randomly chosen, female participants on two occasions separated by seven days, to confirm intra-rater agreement. The level of scoring agreement between the two sessions was assessed using the weighted kappa statistic (k).²⁴ Agreement levels were defined as follows: <0 less than chance agreement, 0.01–0.20 slight agreement, 0.21–0.40 fair agreement, 0.41–0.60 moderate agreement, 0.61–0.80 substantial agreement, and 0.81–0.99 almost perfect agreement.²⁴

Procedure

Participants' anthropometric characteristics (e.g., height, mass) were recorded as described previously.²¹ Participants completed a standardised warm-up involving the assessment task movements as instructed by the primary

researcher. Participants carried out the AAA in training shorts and sports bra/singlet on an outdoor rubber matting floor at their usual training facilities, prior to their first scheduled training session of the pre-season. Each athlete completed five repetitions of each AAA battery task in the following order, overhead squat, right then left single leg lunge, right and left Romanian deadlift, and push up. The entire AAA battery was completed within five minutes with 15 s of rest between each trial and 30 s of rest between tasks. Movements were recorded using standard, two-dimensional cameras (Sony CX405 Full HD Handycam, Singapore), placed in the lateral, frontal and overhead positions (i.e., push-up task to identify scapular movement). Scoring was conducted retrospectively using the video footage and standard criteria (Table 1). The highest score for each movement (from a potential total of 9 arbitrary units) was recorded with a total score calculated out of a maximal score of nine movements totally a potential 54 arbitrary units.²¹ The single scorer (primary investigator) was an experienced anatomist with an Exercise Science undergraduate degree, post graduate PhD in rugby league skill acquisition (including AAA assessment of 174 rugby league athletes), and 12 years' experience as a strength coach.

All data collected (male and female) was collected during similar standardised conditions and analysed by the primary investigator.

Analysis

Mean (\pm standard deviation) scores were calculated for each AAA task and overall battery of the current female and prior male²¹ athlete groups. Additionally, given the variable training experiences reported for female, rugby league athletes,²⁵ a k-means cluster analysis using the six AAA battery task scores was conducted to examine lower-skilled ($n = 13$) and higher-skilled ($n = 17$) groups to assist characterisation of movement competency in adolescent female athletes.²⁶ Comparisons between sexes and between lower- and higher-skilled female groups were conducted via Mann-Whitney U tests given the non-normal distribution of the data. The magnitude of sex and group differences was calculated via Rank-Biserial Correlation coefficients (r) with small (<0.30), moderate (0.30 – 0.49) and large (≥ 0.50) effects noted.²⁷ All analyses were conducted using Jamovi 2.6²⁸ with $p < 0.05$ set as the level of statistical significance.

Results

Inter-rater agreement for scoring the athletic movement skill assessment ranged from substantial to almost perfect, with κ values between 0.65 and 0.88.²⁴ Mean AAA task scores for female athletes ranged between 3.8 and 6.6 with the overall mean AAA total score being ~ 30 out of 54 (Table 2). All mean AAA task scores, except for the push up, and mean AAA total score were significantly different with moderate to large effects compared to age-matched, male athletes (Table 2). Of note was that female athletes scored higher for the left and right single leg lunges compared to male athletes (Table 2).

The lower-skilled females exhibited poorer scores for overhead squat ($r = 0.955$; large effect), left ($r = 0.783$; large effect) and right ($r = 0.819$; large effect) single leg lunge, and AAA battery total score ($r = 0.814$; large effect; Figure 1). Scores for the push-up ($r = 0.136$; small effect) and left ($r = 0.299$; small effect) and right ($r = 0.330$; moderate effect) Romanian deadlift were similar between lower-skilled and higher-skilled female groups (Figure 1).

Discussion

This study identified lower movement competency in semi-elite adolescent female rugby league players compared with an age-matched male cohort at entry to the talent development pathway. Data analysis revealed a clear delineation within the female cohort, resulting in the identification of lower and higher-skilled groups that potentially require different foci by practitioners. These findings provide the first,

evidence-based, representation of female, adolescent movement competency within rugby league and offers a foundational dataset that may guide researchers, coaches, and sporting organisations in refining assessment protocols, benchmark measures, training design, and athlete development frameworks.

In the current study, sex-based differences were observed, with females demonstrating lower scores most prominently for the Romanian dead lift (RDL) and overhead squat. The RDL and overhead squat are complex, multi-joint strength tasks that place high demands on trunk control, lumbopelvic stability, and coordinated sagittal- and frontal-plane load management, compared with the push up and single leg lunge.¹⁹ These differences likely reflect a combination of reduced exposure to high-load, multi-joint strength tasks during formative development, and sex-specific anatomical and biomechanical characteristics.

Male rugby league has been supported by long-standing, structured development pathways from junior representative to senior competitions since 1910, whereas organised female pathways have only initiated recently, particularly following the introduction of the NRLW in 2018.²⁹ Consequently, the historical disparity in pathway availability suggests that male rugby league systems have been afforded earlier and more continuous exposure to rugby league-specific training demands, whereas female athletes have entered formal pathways only recently (i.e., within the past decade), contributing to greater variability in developmental histories. Subsequently, current training practices and performance benchmarks for rugby league athletes have been largely informed by male-derived models, which may not adequately account for female-specific anatomical and biomechanical characteristics during complex strength and movement tasks. For example, the execution of compound strength tasks for females likely disregards females' wider pelvis, greater anterior chain dominance, increased ligamentous laxity, and reduced musculoarticular stiffness.⁹ Sex-based anatomical and biomechanical differences are evident during fundamental strength-based movements.^{9,30–32} Compared with males, females typically demonstrate greater knee valgus, foot pronation, hip internal rotation and adduction, and increased asymmetry in knee flexion strategies during single leg squat tasks.^{33,34} In contrast, males exhibit greater knee and trunk flexion, lower frontal-plane knee displacement, higher vertical ground-reaction forces, greater reliance on hip-extensor musculature, reduced ankle dorsiflexion at terminal knee extension,^{31,32} and a less lordotic lumbar posture at back-squat initiation.³⁵ Therefore, sex anatomical and biomechanical differences may either enhance or constrain force transfer and movement efficiency during high-demand, whole-body lifting tasks that requires consideration for athletes upon first point entry into the talent development pathway. Consequently, practitioners need to contemplate both training history and sex anatomical and biomechanical

Table 2. Mean \pm standard deviation scores, and magnitude of differences, for each Athlete Ability Assessment (AAA) task and total battery for all female and age-matched male, adolescent, rugby league athletes.

	OH squat	Left SLL	Right SLL	Left RDL	Right RDL	Push-up	AAA total
Female athletes (n = 30)	4.0 \pm 2.0	5.9 \pm 1.4	6.6 \pm 1.7	3.8 \pm 2.4	4.5 \pm 2.3	5.6 \pm 2.4	30.3 \pm 7.9
Male athletes (n = 52)	6.1 \pm 1.6*	4.7 \pm 1.0*	4.8 \pm 1.0*	6.4 \pm 1.0*	6.6 \pm 1.1*	6.2 \pm 1.5	34.7 \pm 4.1*
Rank biserial correlation coefficient (interpretation)	0.556 (large effect)	0.508 (large effect)	0.644 (large effect)	0.628 (large effect)	0.571 (large effect)	0.048 (small effect)	0.415 (moderate effect)

OH = overhead squat; SLL = single leg lunge; RDL = Romanian dead lift; *p < 0.001 vs. female athletes.

differences when working with adolescent rugby league athletes in their optimisation of training practices. Further, earlier exposure to structured training, alongside consideration of female-specific anatomical characteristics, may help reduce observed movement competency disparities over time and enable longitudinal evaluation of the female movement competency continuum. Coach education is therefore critical, with emphasis on recognising female-specific movement patterns, pubertal-related anatomical and neuromuscular changes, and sex-based differences relative to males, in conjunction with the application of appropriate exercise selection, modification, and progression strategies.

Of relevance to practitioners was the presence of both lower- and higher-skilled female athletes entering the same talent development pathway. This heterogeneity likely reflected differences in early sport participation, training exposure, and the interaction between biological maturation and the non-linear remodelling of female anatomy and neuromuscular control.^{9,12} Consequently, adolescent females may enter pathways with markedly different capacities and foundational movement skills. Stratifying training based on AAA performance may allow lower-skilled athletes to prioritise neuromuscular control and foundational movement patterning, while enabling higher-skilled athletes to progress toward strength and power development without compromising movement quality.

Previous studies have reported that short-term neuromuscular training interventions can effectively refine motor patterns, enhance intermuscular coordination, and improve stabilisation strategies that underpin safe and effective strength and conditioning practice.^{36,37} Developing neuromuscular control during adolescence not only reduces injury risk during load-bearing tasks but also establishes the biomechanical readiness required for progression to integrated, kinetic-chain resistance training.³⁸ Given the strong association between movement competency and muscular strength,³⁹ early implementation of neuromuscular training principles within adolescent female development frameworks is critical for establishing a foundation for subsequent lower-limb strength and power enhancement.⁴⁰ Within this context, repeated AAA assessment may provide a practical tool to monitor longitudinal changes in movement quality, inform progression or

regression decisions, and ensure training adaptations align with the physiological demands of biological maturation and injury prevention in female athletes.⁹ Beyond injury reduction,^{41,42} neuromuscular training has also demonstrated improvements in strength, proprioceptive acuity, and movement confidence,^{12,36,43} factors that may enhance training adherence and help mitigate the high attrition rates observed among adolescent female athletes.

Notably, some tasks demonstrated a different pattern of performance. Despite sex-based differences across most AAA tasks, female athletes achieved comparable, and in some cases higher, scores for the push-up and single-leg lunge. These outcomes likely reflect repeated task exposure rather than adaptations from progressive overload or structured strength development. Both tasks closely align with habitual daily and rugby league-specific actions, favouring movement proficiency acquired through exposure rather than systematically progressed loading.⁴⁴

Strengths, limitations and future directions

Collectively, these findings contribute sex-specific evidence relevant to talent identification, load management, and the development of anatomically informed training prescriptions for adolescent rugby league athletes. However, this study was limited by a modest, convenience sample drawn from two clubs. Future research should expand recruitment across multiple developmental stages, from pathway entry to elite competition, to better characterise the progression of movement competency across the talent pathway.

Detailed structured strength and conditioning training history and maturational status were not recorded for either female or male participants. Both cohorts were assessed at initial entry into the formal talent development pathway and originated from heterogeneous school- and community-based sport backgrounds. Although these factors may influence movement competency, their omission reflects real-world talent identification contexts, where detailed training exposure and maturational data are often unavailable at pathway entry.

Future investigations should extend this work by examining longitudinal changes in movement competency across puberty, exploring associations between AAA outcomes, injury history, and physical performance indicators, and

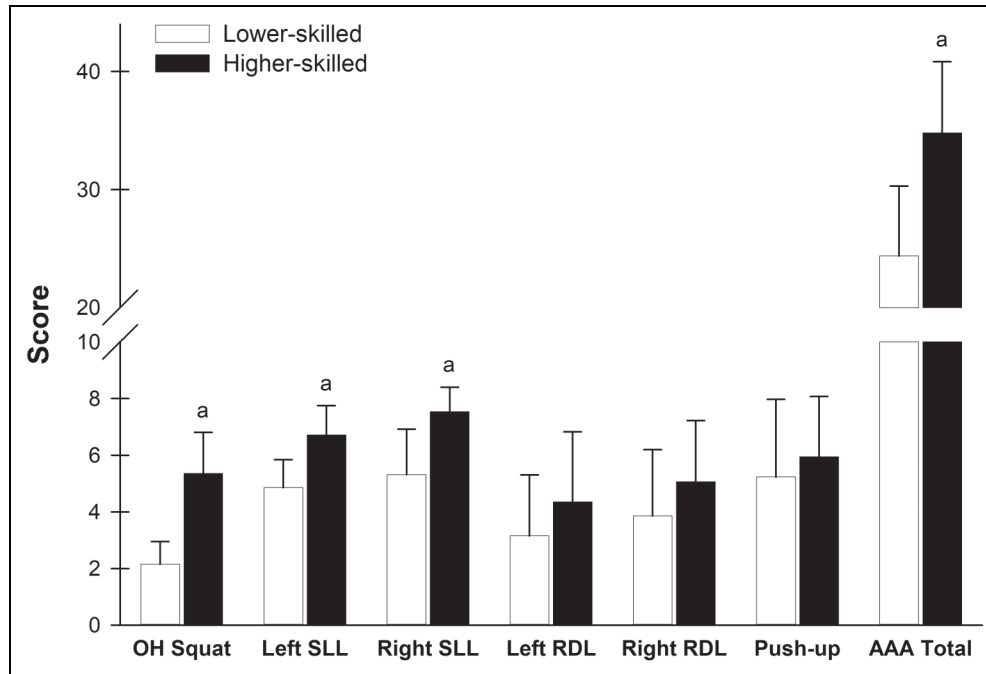


Figure 1. Mean \pm standard deviation scores for each Athlete Ability Assessment (AAA) task and total battery for lower- ($n = 13$) and higher-skilled ($n = 17$) groups of female adolescent rugby league athletes. OH = overhead squat; SLL = single leg lunge; RDL = Romanian dead lift; ^a $p < 0.05$ vs. lower-skilled group.

evaluating the sensitivity of neuromuscular control-based assessment tools, such as the AAA, for monitoring development in adolescent athletic populations.

Conclusion

Despite a convenient sample size, the findings highlighted the poorer movement competency of female adolescent rugby league athletes compared to the corresponding males commencing the talent development pathway. Further, the identification of different skilled groups supported the importance of adopting a movement-competency-led approach to the design and management of strength and conditioning programmes for female, adolescent, rugby league athletes. Sex-specific anatomical and biomechanical considerations, coupled with substantial inter-individual variability in movement proficiency, necessitate early, equitable access to anatomically informed training and targeted coach education. The AAA framework offers a practical and scalable tool to stratify athletes, guide individualised progression, and monitor longitudinal adaptation, supporting safe advancement from neuromuscular control toward integrated strength and power development while addressing both performance capacity and long-term athlete health.

Practical applications

- Prioritise coach education: Coaches and support staff should receive ongoing education in female-specific

anatomy, biomechanics, and pubertal-related changes to ensure exercise selection, cueing, and progression strategies are developmentally appropriate and evidence-based for each female athlete.


- Establish movement benchmarks: Coaches should implement brief, objective assessments of movement competency, such as the AAA, prior to introducing or progressing strength and conditioning programmes. This enables targeted exercise prescription, appropriate stratification within cohorts, and the establishment of measurable benchmarks for monitoring athlete development.
- Stratify training within cohorts: Training should be differentiated based on movement competency, allowing lower-skilled athletes to prioritise neuromuscular control and foundational patterning, while higher-skilled athletes can progress toward strength and power development without compromising movement quality.
- Provide early, equitable exposure: Structured strength and conditioning opportunities for female athletes should be introduced at grassroots and school levels to support movement competency and strength development before adolescence-related disparities widen.

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Ethical considerations

Ethical approval was granted from James Cook University (16956) with all participants and parents/guardians providing written informed consent prior to data collection.

Consent to participate

All participants and parents/guardians provided written informed consent prior to data collection.

Consent for publication

All participants and parents/guardians provided written informed consent for the publication of results.

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Declaration of conflicting interests

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Data availability

The data supporting the findings of this study are not publicly available due to ethical restrictions involving minors. Data may be made available from the corresponding author upon reasonable request and with approval from the James Cook University Human Research Ethics Committee.

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